Spatial Disorientation and Sensory Illusions of Flight
U3004505 / Version 1
08 Nov 2004

SECTION I. ADMINISTRATIVE DATA

All Courses Including This Lesson

Course Number	Version	Course Title
300-F6	2005	Flight Medic
6A-61N9D	05	Flight Surgeon Course (Primary)
6A-61N9D(RC)(P1)	05	Flight Surgeon Course (Primary), Phase I
6H-F27	04D	AEROMEDICAL PSYCHOLOGY TRAINING

Task(s) Taught(*) or Supported

Task Number	Task Title
	INDIVIDUAL
081-839-5506 (*)	PREVENT PHYSIOLOGICAL EFFECTS OF SPATIAL DISORIENTATION
081-CF9-0007 (*)	MANAGE THE EFFECTS OF SPATIAL DISORIENTATION IN FLIGHT

Reinforced Task(s)

Task Number	Task Title
01-1414.00-0200	Manage Aeromedical Factors in Aviation

Academic Hours

The academic hours required to teach this lesson are as follows:

	Resident Hours/Methods
	2 hrs 15 mins / Conference / Discussion
	35 mins / Demonstration
Test	0 hrs
Test Review	0 hrs
Total Hours:	3 hrs

Test Lesson Number

	Hours	Lesson No.
Testing (to include test review)		N/A

Prerequisite Lesson(s)

Lesson Number	Lesson Title
None	

Clearance Access

Security Level: Unclassified
Requirements: There are no clearance or access requirements for the lesson.

Foreign Disclosure Restrictions

FD5. This product/publication has been reviewed by the product developers in coordination with the USASAM foreign disclosure authority. This product is releasable to students from all requesting foreign countries without restrictions.

References

Number	Title	Date	Additional Information
0-7817-2898-3	Fundamental of Aerospace Medicine, 3rd Edition		
FM 3-04.301	Aeromedical Training for Flight Personnel	29 Sep 2000	

Student Study Assignments

Study SH and review reference material listed above.

Instructor Requirements

One instructor, 67J or 91W3F.

Additional Support Personnel Requirements

Name	Stu Ratio	Qty	Man Hours
None			

Equipment Required for Instruction

Id Name	Stu Ratio	Instr Ratio	Spt	Qty	Exp
COMPU-PR0J OVERHEAD PROJECTOR W/ COMPUTER INTERFACE	1:50		No	0	No
COMPUTER-INSTRUCTOR COMPUTER (CPU) WITH KEYBOARD, INSTRUCTOR USE ONLY	1:50		No	0	No
MONITOR-INSTRUCTOR COMPUTER MONITOR, INSTRUCTOR USE ONLY	1:50		No	0	No
SCREEN-INSTRUCTOR SCREEN PROJECTOR, INSTRUCTOR USE	1:50		No	0	No

* Before Id indicates a TADSS

Materials Required

Instructor Materials:
Lesson plan for Spatial Disorientation and Sensory Illusions in Flight and FM 3-04.301.

Student Materials:
Spatial Disorientation and Sensory Illusions in Flight Student handout.

Classroom, Training Area, and Range Requirements

BARANY CHAIR TRAINING AREA, 600SF, 80PN

Ammunition Requirements	Id	Name	Exp	Stu Ratio	Instr Ratio	Spt Qty
	None					

Instructional Guidance

NOTE: Before presenting this lesson, instructors must thoroughly prepare by studying this lesson and identified reference material.

The instructor will be trained in the safe operation of the Barany Chair prior to using it for the demonstrations.

Proponent Lesson Plan Approvals

Name	Rank	Position	Date
Schwab, Douglas	SFC	NCOIC, Flight Physiology	01 Dec 2004
Bost-Pittman, Carolyn	DAC	ISS	07 Dec 2004
Campbell, John	LTC	Dean	09 Dec 2004

SECTION II. INTRODUCTION

Method of Instruction:	Conference / Discussion
Instructor to Student Ratio is:	1:50
Time of Instruction:	10 mins
Media:	Large Group Instruction

Motivator

"Throughout the evolution of man, he has acquired sensory systems well suited for maneuvering under his own power on the surface of the earth, but poorly suited for flying. The sudden entry into the aerial environment resulted in a mismatch between the orientation demands of the new environment and the innate ability to orient oneself. The manifestation of this mismatch is spatial disorientation. Spatial disorientation contributes more to aircraft accidents than any other physiological problem in the aerial environment. From 1987 to 1995, 291 class A-C accidents were directly related to spatial disorientation. The results of these accidents were 110 fatalities and over 468 million dollars in damage to the aircraft. It can strike at virtually anytime and place and in any mode of flight. Our goal today is to familiarize you with spatial disorientation so when you do experience it, you are able to recognize what is happening and overcome the effects."

Terminal Learning Objective

NOTE: Inform the students of the following Terminal Learning Objective requirements.

At the completion of this lesson, you [the student] will:

Action:	Manage the effects of spatial disorientation in flight.
Conditions:	While performing as an aircrew member.
Standards:	In accordance with (IAW) FM 3-04.301and the Fundamentals of Aerospace Medicine.

Safety Requirements

None.

Risk Assessment Level

Low

Environmental Considerations

NOTE: It is the responsibility of all soldiers and DA civilians to protect the environment from damage.
None.

Evaluation

NOTE: Use it, paraphrase it, or develop one of your own. Ensure you include how, when, where, and length of test.

"Each student will be evaluated on this block of instruction during the 50 question comprehensive aeromedical exam. This exam will be conducted on the last day of aeromedical training in building 301, classroom x-110."

Instructional Lead-In

The classes you have attended here at the School of Aviation Medicine have prepared you to manage the effects of flight on the human body. Today we will continue that training be discussing the effects of spatial disorientation and sensory illusions.

SECTION III. PRESENTATION

NOTE: Inform the students of the Enabling Learning Objective requirements.

A. ENABLING LEARNING OBJECTIVE

ACTION:	Identify the terminology associated with spatial disorientation.
CONDITIONS:	While serving as an aircrew member.
STANDARDS:	IAW: FM 3-04.301 and The Fundamentals of Aerospace Medicine.

1. Learning Step / Activity 1. Provide instruction on spatial disorientation terminology.

Method of Instruction: Conference / Discussion
Instructor to Student Ratio: 1:50
Time of Instruction: 5 mins
Media: Large Group Instruction

a. Vertigo: A sensation of spinning or dizziness. The term vertigo is often misused by aircrew members as a generic term to represent all forms of spatial disorientation that they may experience.

b. Sensory illusion: A false perception of reality caused by the conflict of orientation information from one or more mechanisms of the equilibrium. Sensory illusions are a major cause of spatial disorientation.

c. Spatial disorientation: Spatial disorientation is a subset of situational awareness. It is the inability to determine one's position, attitude, and motion relative to the surface of the earth or other significant objects (i.e., trees, poles, or buildings).

d. Orientation or equilibrium: Orientation or equilibrium involves an individual's accurate perception of their position, attitude, and motion relative to the earth.

(1) The body has five traditional senses: Vision, hearing, touch, smell, and taste. With the possible exception of the latter two, all contribute to our perception of orientation. The sensory inputs that provide orientation all act simultaneously. Orientation is achieved through a continuos “loop” of sensation and feedback.

(2) The sensory inputs that provide orientation and equilibrium are the visual, vestibular, and proprioceptive systems.

NOTE: Conduct a check on learning and summarize the learning activity.

CHECK ON LEARNING: <u>NOTE</u>: Conduct a check on learning and summarize the ELO.

B. ENABLING LEARNING OBJECTIVE

ACTION:	Identify the role of vision in orientation.

CONDITIONS:	While serving as an aircrew member.
STANDARDS:	IAW FM 3-04.301 and the Fundamentals of Aerospace Medicine.

1. Learning Step / Activity 1. Provide instruction on the role of vision in orientation.

Method of Instruction: Conference / Discussion
Instructor to Student Ratio: 1:50
Time of Instruction: 10 mins
Media: Large Group Instruction

a. Vision is overwhelmingly the most important bodily sense of orientation. During flight, 80 percent of orientation is dependent on the visual sense. When the visual system is functioning normally, the vestibular and proprioceptive systems complement the visual system providing us our optimum orientation or situational awareness. During flight, in the absence of the visual system, the vestibular and proprioceptive system can be unreliable.

b. Role of visual cues: Orientation by vision requires perception, recognition, and identification. In other words, a person must determine their position by understanding where other objects are in relation to themselves.

c. The visual system is comprised of two modes, focal and ambient vision. When good focal and ambient visual cues are present, vision is dominant, and attention to the other orientation senses is often minor or easily suppressed..

d. Focal vision: The focal or central vision allows us to perceive images clearly. Focal vision involves relatively fine detail.

(1) Focal vision is concerned with object recognition and identification. For instance, when we read a book or look at our flight instruments we are utilizing our focal vision.

(2) Focal vision cues provide the primary means by which judgments of distance and depth are made. The images we perceive throughout our lifetime are stored in memory so that we may compare their size to our own position relative to them. (For example, a five ton cargo truck is of a known size, therefore, we can judge our distance from it, depending on its retinal projection.)

e. Ambient or peripheral vision: Responsible for orienting us within our environment.

(1) It is the primary mode for detecting motion, although it has poor acuity properties.

(a.)Its function is largely independent of the function of focal vision.

(b.) One can fully occupy central vision with the task of reading while simultaneously obtaining sufficient orientation cues with peripheral vision to walk or ride a bicycle.

(2) In the absence of the horizon, visual cues arising in the ambient visual field can easily be misinterpreted and lead to disorientation.

(3) Peripheral vision detects motion, either our own motion or motion of other objects around us. (For example, when we view a movie on a wide screen such as flying an airplane through the Grand Canyon, we perceive ourselves in motion.)

(4) Peripheral vision provides adequate orientation information in absence of the perception of information from the vestibular apparatus. An individual can still maintain balance through the use of the peripheral visual mechanism of orientation.

f. Conditions for spatial disorientation: Current research has shown that the absence of visual cues at a hover is the most likely predisposing condition for spatial disorientation.

NOTE: Conduct a check on learning and summarize the learning activity.

CHECK ON LEARNING: NOTE: Conduct a check on learning and summarize the ELO.

C. ENABLING LEARNING OBJECTIVE

ACTION:	Identify the visual illusions.
CONDITIONS:	While serving as a crew member.
STANDARDS:	IAW FM 3-04.301 and the Fundamentals of Aerospace Medicine.

1. Learning Step / Activity 1. Provide instruction on the visual illusions.

Method of Instruction: Conference / Discussion
Instructor to Student Ratio: 1:50
Time of Instruction: 25 mins
Media: Large Group Instruction

a. Visual illusions may occur when visual cues are reduced by clouds, night, and/or other obscurities to vision.

(1) False horizon: The false horizon illusion occurs when the aviator confuses cloud formations with the horizon or the ground. This illusion occurs when an aviator subconsciously chooses the only reference point available for orientation.

(a) A sloping cloud deck may be difficult to perceive as anything but horizontal if it extends for any great distance in the pilot's peripheral vision. An aviator may perceive the cloud bank below to be horizontal although it may not be horizontal to the ground, thus flying the aircraft in a banked attitude.

(b) This condition is often insidious and goes undetected until the aviator recognizes it and transitions to the instruments and corrects appropriately.

(c) This illusion can also occur if an aviator looks outside after having given prolonged attention to a task inside the cockpit. The confusion may result in the aviator placing the aircraft parallel to the cloud bank.

(2) Fascination or fixation: Occurs when aircrew members ignore orientation cues and focus their attention on their object or goal.

(a) Fixation: Target fixation, commonly referred to as target hypnosis, occurs when an aircrew member ignores orientation cues and focuses their attention on their object or goal. For example, an attack pilot on a gunnery range becomes so intent on hitting the target, he forgets to fly the aircraft, resulting in the aircraft striking the ground, the target, or the shrapnel created by hitting the target.

(b) Fascination: may occur during the accomplishment of simple tasks within the cockpit. Crew members may become so engrossed with a problem or task that they fail to properly scan outside the aircraft.

(c) Other types of fascination are associated with wheels-up landings, rigid fixation on the lead aircraft during formation flight, and over concentration on one instrument during instrument flight.

(3) Flicker vertigo is technically not an illusion, however, as most people are aware from personal experience, viewing a flickering light can be both distracting and annoying.

(a) Flicker vertigo may be created by helicopter rotors blades or airplane propellers interrupting direct sunlight at a rate of 4 to 20 cycles per second.

(b) Other sources include such things as anti-collision strobe lights flashing, especially while in the clouds. One should also be aware that photic stimuli at certain frequencies can produce seizures in those rare individuals who are susceptible to flicker-induced epilepsy.

(4) Confusion with ground lights: Occurs when an aviator, mistakes ground lights for stars. This illusion prompts the aviator to place the aircraft in an unusual attitude to keep the misperceived ground lights above them.

(a) Isolated ground lights can appear as stars and this could lead to the illusion that the aircraft is in a nose high or one wing low attitude.

(b) When no stars are visible due to overcast conditions, unlighted areas of terrain can blend with the dark overcast to create the illusion that the unlighted terrain is part of the sky. This illusion can be avoided by referencing the flight instruments and establishing of a true horizon and attitude.

(5) Relative motion is the falsely perceived self-motion in relation to the motion of another object.

EXAMPLE: You are sitting in a car stopped at a stop light and unconsciously reduce your scan outside the vehicle. Your peripheral (ambient) vision detects the motion of another car pulling up along side your car. You perceive the forward motion of the car beside you as the rearward motion of your own vehicle. Alarmed, you slam on the brakes.

(b) The relative motion illusion can also occur during formation flight. The forward, aft, up, or down movement of a lead or trailing aircraft may be misinterpreted as movement of your own aircraft in the opposite direction.

(c) The relative motion illusion can also occur to helicopter pilots hovering over water or tall grass. The rotor wash creates a continual waving motion, which makes it difficult to maintain a stationary hover point.

(6) Altered planes of reference: Inaccurate sense of altitude, attitude, or flight path position in relation to an object very great in size so that the object becomes the new plane of reference rather than the correct plane of reference; the horizon.

(a) A pilot approaching a line of mountains may feel the need to climb although their altitude is adequate. This is because the horizon, which helps the pilot maintain orientation, is subconsciously moved to the top of the ridge line. Without an adequate horizon, the brain attempts to fix a new horizon.

(b) Conversely, an aircraft entering a valley, which contains a slowly increasing up-slope condition, may become trapped because the slope may quickly increase and exceed the aircraft's ability to climb above the hill, causing the aircraft to crash into the surrounding hills.

(c) When flying next to large cloud formations, the eyes may interpret the cloud formations as a horizon. The tendency would be to tilt away from the clouds.

(7) Structural illusions: Structural illusions are caused by heat waves, rain, snow, sleet, or other visual obscurants.

(a) A straight line may appear curved when viewed through heat waves.

(b) Heavy rain against aircraft windshields may cause a pilot on half-mile final to perceive the runway as being 200 feet further away.

(8) Height-depth perception illusion: Due to a lack of sufficient visual cues, the aircrew member will experience the illusion that they are higher above the terrain than they actually are.

(a) Flying over an area devoid of visual references, such as desert, snow, or water will deprive the pilot of his perception of height.

(b) Flight in an area where visibility is restricted by fog, smoke, or haze produces the same illusion.

(9) Crater illusion: When landing at night, the position of the landing light may be too far under the nose of the aircraft. This will cause the illusion of landing into a hole (crater).

(10) The size-distance illusion: A false perception of distance from an object or the ground, created when a pilot misinterprets an unfamiliar object's size to be the same as an object he/she is normally accustomed to viewing.

(a) An aircraft hovering close by with its dim position lights on, may appear to be farther away than when viewed at the same distance with its lights on bright.

(b) This illusion also occurs if the visual cues, such as trees, are of a different size than expected. For example, the small trees of the Midwest have the same shape and contrast as the tall trees of the east coast. The pilot may fly his aircraft dangerously low, thinking that he is further away from the ground.

(c) A pilot may falsely perceive an unfamiliar LZ to be the same size as to which he is used to landing. For example, a pilot who is used to landing at an airfield with a large runway 200 feet wide and 5,000 feet long, may fly too low if making the same approach to a small airstrip of 100 feet wide, 2,000 feet long.

(11) Autokinesis: The autokinetic illusion results when a static light appears to move when it is stared at for several seconds. Uncontrolled eye movement may possibly cause the illusion of movement as the eye attempts to find some other visual reference points.

(12) Reversible perspective: At night, an aircraft may appear to be going away when it is actually approaching. This illusion is often experienced when an aircrew member observes an aircraft flying a parallel course. To determine the direction of flight, the aircrew member should observe the position of the aircraft lights (red, right, return).

NOTE: Conduct a check on learning and summarize the learning step/activity.

NOTE: Conduct a check on learning and summarize the learning activity.

CHECK ON LEARNING: NOTE: Conduct a check on learning and summarize the ELO.

D. ENABLING LEARNING OBJECTIVE

ACTION:	Identify the function of the vestibular system.
CONDITIONS:	While serving as an aircrew member.
STANDARDS:	IAW FM 3-04.301and the Fundamentals of Aerospace Medicine.

1. Learning Step / Activity 1. Provide instruction on the function of the vestibular system.

Method of Instruction: Conference / Discussion
Instructor to Student Ratio: 1:50
Time of Instruction: 10 mins
Media: Large Group Instruction

a. Even when deprived of vision, we can still sense our orientation to gravity as well as movement occurring during activity. Part of this ability for orientation is due to the organ of equilibrium found in the inner ear, the vestibular apparatus. The vestibular system detects the position, motion and acceleration of the head in space.

Although we are not usually aware of the vestibular system, as we are with sight, hearing, touch, and smell, it is essential for motor coordination, eye movements and posture.

b. The Vestibular system: The vestibular apparatus consists of three parts: the semicircular canals, vestibule, and the cochlea.

(1) These end organs are small, measuring just 1.5 cm across. They reside well protected within some of the densest bone in the body, the petrous portion of the temporal bone.

(2) Within the vestibule lie the otolith organs. Both the semicircular canals and the otolith organs interact together, providing vital information to the brain about motion and orientation in Earth's gravity. The vestibular apparatus is sensitive to pressure changes within the atmosphere and can be affected by upper respiratory infections.

c. Vestibular function: The function of the vestibular system in spatial orientation is not so overt as that of vision but is extremely important for three major reasons: Visual tracking, reflex information, and orientation in the absence of vision.

(1) Visual tracking is most important function of the vestibular system. It provides input to the brain to trigger reflex mechanisms in the eyes so that when the head is turned, they can track an object accurately to prevent a blurred image on the retina.

(a) The brain requires the eyes to present a clear picture. The clear picture is easily accomplished when the head and body are still. Imagine what would happen to the picture if you were to turn to the right while still maintaining the image in sight. The images would pass across the retina, as the head is turned, which would create a blurred image.

(b) The vestibular apparatus tells the brain to send the eyes in an opposite direction of the turn. So, if you were to turn your head to the right, your eyes would deflect left, thereby, keeping the image in focus.

(c) To demonstrate the vestibular function, hold your hand at eye level so that the palm is facing you. Now, turn your head rapidly from side to side. The image of your palm should remain clear. Now, move your hand back and forth in front of your eyes; the image becomes blurred. This image is what you would see if you did not have a vestibular apparatus.

(d) This reflex mechanism is responsible also for a condition known as nystagmus.

1. Nystagmus is the jerky undulating movements that appear when the eyes are unable to maintain steady fixation. It consists of jerk movements induced by repeatedly moving stimuli across the visual field.

Example: Nystagmus occurs in an aviator trying to track multiple objects moving counter to the direction of the aviator. The eye movements which cause nystagmus occur in two phases. The slow phase movement occurs when the eyes follow a target. The fast phase is seen as a quick movement in the opposite direction returning the eyes to a neutral position. As the peripheral area of the retina is stimulated, this ensures that the eyes fixate on the next target that enters the field of vision. Reduced acuity is caused by the inability of the eyes to maintain steady fixation.

2. The involuntary, a rapid eye movement that occurs with Nystagmus will prevent the aviator focusing inside or outside the cockpit for a short period of time. Experiencing Nystagmus during flight conditions such as nap of the earth can produce fatal results.

(2) Reflex information: The vestibular apparatus provides reflex information by providing the brain with information on the body's activities. This is accomplished through what is called vestibulospinal reflexes. They operate to ensure stability of the body.

(a) Transient linear and angular accelerations, such as tripping and falling, provoke rapid activation of various muscle groups to return the body to a stable position. For example, if one were to fall forward, the arms would come up to break the fall.

(b) Reflex information is also responsible for overpowering spontaneous, instinctive inputs into the flight controls that are not the necessarily the correct inputs. Instinctive, spontaneous imputes into the flight controls due a spontaneous reaction may be difficult to overcome. This can only be avoided through continuous training and education.

(3) Orientation without vision: The vestibular apparatus provides the brain the necessary orientation information when there is an absence of vision.

(a) If we did not have the vestibular mechanism providing additional orientation information, we would not be able to walk in complete darkness. We would always lose our balance and fall.

(b) The body receives information during turns and rolls even when the eyes aren't providing this information.

c. Components of the vestibular system:

(1) Semicircular canals:

(a) The semicircular canals are arranged at right angles to each other enabling them to detect angular acceleration in the yaw, pitch, and roll axis. Each semicircular canal is comprised of three canals, an ampula, and a cupula.

(b) The semicircular canals contain endolymph fluid which is allowed to travel freely throughout the vestibular cavities. When angular acceleration is applied to the body, the semicircular canals and endolymph fluid are also accelerated. However, the fluid within the canals lags behind the moving canal walls.

(c) The motion of the lagging endolymph fluid, causes a gelatinous structure, the cupula, to bend or deviate in the opposite direction of the fluid movement. If in a right turn or clockwise rotation, the cupula is deflected left. The cupula, when bent, stimulates hair cells termed cilia, located beneath the cupula. This, in turn, sends nerve impulses via the vestibular nerve to the brain. The cupula is located at the enlarged base of the canal called the ampulla. These impulses are interpreted as rotation of the head. When no acceleration takes place, the cupula remains in a steady state.

EXAMPLE: When a glass of water is rotated, the water lags behind the direction of rotation until friction
between the glass and the water pulls the water to the same speed of the turning glass. This action is the same for the endolymph fluid within the semicircular canals.

(d) Fluid movement within the canals only takes place during the periods of acceleration. If the turn is prolonged and remains constant, the endolymph catches up with the canal wall and the canal reaches equilibrium. The cupula is no longer deviated and the brain receives the false impression that the turn has stopped.

(e) If the turn is reduced and thus acceleration is reduced, the endolymph inertia will continue in the direction of the turn while the canal wall is slowed. This results in the deflection of the cupula in the opposite direction. The brain then receives a false impression of an opposite turn.

(2) Otolith organs:

(a) The vestibule contains two otolith organs, the utricle, and the saccule. The utricle is a sac-like inner ear organ containing otoliths which sense forward and backward motion of the head. The saccule is a sac-like inner organ containing otoliths which senses vertical motion of the head. Together, they translate gravitational and linear inertial forces into spatial orientation information, specifically, information about tilt and linear motion of the head (Forward, aft, up, and down). Both organs are dependant on gravitational and inertial forces.

(b) The otolith organs consist of plate-like congregations of sensory cells (cilia), which project up into a gelatinous layer, the otolithic membrane. This membrane is filled with small calcium carbonate crystals or othilithic stones. The calcium carbonate plate is very dense. It shifts when the head is subjected to linear acceleration.

(c) When the cilia are bent by the fore and aft shift of this membrane, they send nerve impulses to the brain. These impulses are interpreted as movement of the body or head: such as head tilt forward or falling forward.

(d) For example, when the head is tilted backward, the gelatinous layer is shifted, thereby bending the cilia. The brain receives signals that the head is tilted backward.

NOTE: Conduct check on learning and summarize the learning step/activity.

NOTE: Conduct a check on learning and summarize the learning activity.

CHECK ON LEARNING: NOTE: Conduct a check on learning and summarize the ELO.

E. ENABLING LEARNING OBJECTIVE

ACTION:	Identify vestibular illusions.
CONDITIONS:	Whle serving as an aircrew member..

STANDARDS:	IAW: FM 3-04.301 and the Fundamentals of Aerospace Medicine.

1. Learning Step / Activity 1. Provide instruction on the vestibular illusions.

Method of Instruction: Conference / Discussion
Instructor to Student Ratio: 1:50
Time of Instruction: 15 mins
Media: Large Group Instruction

<u>NOTE</u>: Vestibular illusions of flight usually occur when the pilot is deprived of a visual horizon and is involved in accelerative and decelerative flight.

a. Somatogyral illusions: Illusions created when the body is turning or when it is subjected to angular acceleration for prolonged periods. It is the inability of the semicircular canals to register accurately a prolonged rotation.

(1) The leans: The most common form of spatial disorientation. Usually occurs when an aircrew member lacks visual cues for orientation.

(a) Characterized by a false sensation of bank when the aircraft is in level flight.

(b) The leans are caused when a pilot allows the aircraft to enter into an imperceptible turn for several seconds. The semicircular canals will not detect the roll if the rate of roll is less than 2 degrees per second (sub-threshold maneuver).

(c) Some time afterward, the pilot may become aware of the wing-low attitude from reference to the instruments and initiate a recovery to level flight.

(d) This maneuver will stimulate the semicircular canals such that, the pilot will perceive a banked attitude in the opposite direction of the initial turn. The vestibular system will tell the pilot they are now turning. The false sensation of bank can persist for several minutes.

(e) The failure to perceive the initial sub-threshold roll, and then the conflict between the correct visual perception of straight and level and the vestibular perception of a false turn causes the pilot to lean in the initial roll. The result is the pilot's subconscious attempt to reduce the conflict between the visual and vestibular system.

(2) Graveyard spiral:

(a) Usually occurs in a fixed-wing aircraft but can occur in rotary-wing aircraft.

(b) The pilot unknowingly enters a coordinated steep descending spiral, which falsely stimulates the semicircular canals.

(c) If a pilot unknowingly enters a turn of less than 2 degrees per second, the pilot will have the false perception of straight and level flight. However, the aircraft will be descending in a turn.

(d) Upon recovery from the prolonged spiral to straight and level flight, the pilot will experience a sensation of turning in the opposite direction. This is because the fluid remains in motion, which deflects the cupula. This makes him/her feel as though he/she were turning in the opposite direction.

(e) If the pilot is inexperienced, the pilot may correct for the false impression by entering back into the original spiral direction.

(f) The rates of descent in a spiral are extremely high, therefore quick action is necessary to overcome this type of illusion.

(3) Coriolis illusion:

(a) This is the most dangerous vestibular illusion because of its overwhelming and incapacitating effects.

(b) The Coriolis illusion may occur when a prolonged turn is initiated and the pilot makes a head motion in a different geometric plane.

(c) When a pilot enters a turn and then remains in the turn, the semicircular canal corresponding to the yaw axis is equalized. The endolymph fluid no longer deviates the cupula.

(d) If the pilot initiates a head movement in another geometric plane other than that of the turn, the yaw axis semicircular canal is moved from the plane of rotation to a new plane of nonrotation. The fluid then slows down in that canal, resulting in a sensation of a turn opposite that of the original turn.

(e) Simultaneously, the two other canals are brought within a plane of rotation. The fluid then stimulates the two other cupulaes.

(f) The combined effect of the cupla deflection in all three canals, creates the perception of motion in three different planes of rotation: yaw, pitch, and roll. The pilot will experience a very strong tumbling sensation.

b. Somatogravic illusions: Illusions produced when the body is subjected to gravito-inertial (simulated gravity produced by acceleration) forces whereby the pilot falsely perceives a nose high or nose low attitude during changes in linear acceleration (up and down, fore and aft).

(1) Oculoagravic illusion: Movement of the eyes during weightlessness.

(a) The oculoagravic illusion results from a rapid downward motion of the aircraft. Usually occurring during a down draft condition or during rapid descent from a hover condition.

(b) The vertical stimulation of the otolith organ produces an upward shift of gaze in the eyes. The eyes then sense a movement of the aircraft instrument panel in a downward motion.

(c) This results in a sensation that the aircraft is in a nose-low attitude (diving).

(d) The pilot will then erroneously correct for the perceived condition by pulling aft cyclic.

(2) The elevator illusion:

(a) Occurs during upward acceleration.

(b) The upward vertical stimulation of the otolith organ produces a downward shift of gaze in the eyes. The eyes then detect movement of the aircraft instrument panel in an upward motion.

(c) Normal pilot response is to push forward on the cyclic to reduce perceived nose up attitude.

(3) Oculogravic illusion: Visual perception altered as a result of unfamiliar exposure to accelarative and decelerative gravito-inertial forces.

(a) When an aircraft accelerates forward, as in a takeoff or added power condition, a gravito-inertial force is applied to the head in a rearward motion.

(b) The otolith organ (utricle) is shifted to the rear just as if the head were tilted backward. This movement of the membrane is the same movement that would occur if the head were tilted backward.

(c) The otolith organ sends erroneous signals to the brain that the head is tilting backwards. This signal results in the pilot sensing a nose high attitude.

(d) The normal reaction is to push forward on the cyclic and dive the aircraft to overcome the sensation of an excessive climb.

(e) The decelerative version of the oculogravic illusion is an illusion of pitch nose down on sudden deceleration and is more frequent in rotary wing flight than the accelerative version. It can occur when an aircraft decelerates, such as a landing or reduced power condition, the gravito-inertial motion is applied to the head in a forward motion.

NOTES: Select volunteers for demonstration of nystagmus, coriolis, and leans.

NOTE: Conduct a check on learning and summarize the learning activity.

CHECK ON LEARNING: NOTE: Conduct check on learning and summarize the ELO.

F. ENABLING LEARNING OBJECTIVE

ACTION:	Demonstrate Vestibular illusions
CONDITIONS:	Given a barany chair
STANDARDS:	IAW: FM 3-04.301and the Fundamentals of Aerospace Medicine.

1. Learning Step / Activity 1. Demonstration of Vestibular illusions

Method of Instruction: Demonstration
Instructor to Student Ratio: 1:50
Time of Instruction: 35 mins
Media: ACTUAL EQUIPMENT

NOTE: Follow pocedures listed in PE1.

NOTE: Conduct a check on learning and summarize the learning activity.

CHECK ON LEARNING: **NOTE:** Conduct a check on learning and summarize the ELO.

G. ENABLING LEARNING OBJECTIVE

ACTION:	Identify the proprioceptive mechanism of equilibrium.
CONDITIONS:	While serving as an aircrew member.
STANDARDS:	IAW FM 3-04.301 and the Fundamentals of Aerospace Medicine.

1. Learning Step / Activity 1. Provide instruction on the proprioceptive system.

Method of Instruction: Conference / Discussion
Instructor to Student Ratio: 1:50
Time of Instruction: 10 mins
Media: Large Group Instruction

NOTE: The nonvestibular proprioceptors (seat of the pants) make up the third mechanism for equilibrium.

a. There are a variety of sensory nerve endings contained within the muscles, tendons, and joints, and skin.

(1) These nerve endings provide orientation cues to the brain while on the ground as well as in flight.

(2) The nerve endings respond to pressure created by gravity or inertial forces. For example, when we sit, pressure on the buttocks sends signals to the brain, providing orientation information.

b. Seat of the pants flying:

(1) In the absence of visual cues, a pilot will be unable to maintain a level attitude because the proprioceptive system detects gravito-inertial forces that are often inaccurate.

(2) Information from the proprioceptors does not necessarily reinforce orientation information from the visual and vestibular system. The information provided by the proprioceptive system might be misleading, which is why aviators should not rely solely upon seat of the pants flying.

(a) During a turn, the downward forces of gravity coupled with the outward centrifugal forces, creates a resultant force. The resultant force is dependent on the size and force of the two vectors.

(b) This resultant force pulls the aircrew member toward his seat regardless of the speed or direction of the turn. The aviator will experience the perception of turning as well as the false perception that the aircraft is climbing simultaneously. Upon the completion of the turn, the aviator will no longer be pulled down into the seat resulting in the cessation of the turn as well as the false perception that the aircraft is descending.

(3) The proprioceptive mechanism is unreliable in the absence of vision while in flight. An aviator must not try to fly by what they feel is right when deprived of the visual sense.

NOTE: Conduct a check on learning and summarize the learning activity.

CHECK ON LEARNING: <u>NOTE</u>: Conduct check on learning and summarize the ELO.

H. ENABLING LEARNING OBJECTIVE

ACTION:	Identify the types of spatial disorientation.
CONDITIONS:	While serving as an aircrew member.
STANDARDS:	IAW FM 3-04.301 and the Fundamentals of Aerospace Medicine.

1. Learning Step / Activity 1. Provide instruction on the types of spatial disorientation.

Method of Instruction: Conference / Discussion
Instructor to Student Ratio: 1:50
Time of Instruction: 5 mins
Media: Large Group Instruction

a. Type I (unrecognized): Pilot does not perceive any indications of spatial disorientation. In other words, he has no apparent orientation problems. Type I disorientation is the most dangerous type of disorientation, because the pilot is unaware of a problem and fails to correct the disorienting situation. This type of disorientation usually results in aircraft mishaps.

(1) The pilot may see the instruments as functioning properly.

(2) There may be no indications of aircraft control malfunction.

(3) An example of this type of SD would be the height/depth perception illusion where the pilot inadvertently flies the aircraft into the ground due to lack of visual cues.

b. Type II (recognized): Pilot perceives a problem (resulting from spatial disorientation) but may not recognize it as spatial disorientation.

(1) The pilot may feel that a control malfunction is occurring.

(2) The pilot may perceive an instrument failure as in the graveyard spiral, a classic example of Type II disorientation. The pilot does not correct the aircraft roll as indicated on the attitude indicator because his false vestibular indications of straight and level are so strong.

c. Type III (incapacitating): Pilot experiences an overwhelming sensation of movement, such that he/she cannot properly orient himself/ herself by using the aircraft instruments.

NOTE: Conduct a check on learning and summarize the learning activity.

CHECK ON LEARNING: NOTE: Conduct check on learning and summarize the ELO.

I. ENABLING LEARNING OBJECTIVE

ACTION:	Identify the dynamics of spatial disorientation.
CONDITIONS:	While serving as an aircrew member.
STANDARDS:	IAW: FM 3-04.301 and the Fundamentals of Aerospace Medicine.

1. Learning Step / Activity 1. Provide instuction on the dynamics of spatial disorientation.

Method of Instruction: Conference / Discussion
Instructor to Student Ratio: 1:50
Time of Instruction: 5 mins
Media: Large Group Instruction

a. Visual dominance:

(1) A learned phenomena whereby one uses focal visual cues while excluding other sensory cues.

(2) Very complex and fragile skill. Can be lost due to events that disrupt concentration on flying the aircraft.

(3) Acquired through training.

b. Vestibular suppression: Active process of visually overriding undesirable vestibular sensations.

EXAMPLE: Vestibular suppression is when a figure skater stops spinning and doesn't feel dizzy or overcome by Nystagmus.

c. Vestibular opportunism: The propensity of the vestibular system to fill an orientation void swiftly.

NOTE: Conduct a check on learning and summarize the learning activity.

CHECK ON LEARNING: NOTE: Conduct a check on learning and summarize the ELO.

J. ENABLING LEARNING OBJECTIVE

ACTION:	Identify the measures to prevent spatial disorientation.
CONDITIONS:	While serving as an aircrew member.
STANDARDS:	IAW: FM 3-04.301 and the Fundamentals of Aerospace Medicine.

1. Learning Step / Activity 1. Provide instruction on the measures used to help prevent spatial disorientation.

Method of Instruction: Conference / Discussion
Instructor to Student Ratio: 1:50
Time of Instruction: 10 mins
Media: Large Group Instruction

NOTE: Spatial disorientation can't be totally prevented, however, the possibility of spatial disorientation occurring can be reduced by using the following measures.

a. Aviation training:

(1) Training is the most important measure to reduce the possibility of spatial disorientation. Through training, an aircrew member learns the "how’s" and "why's" of spatial disorientation. An aircrew member must understand the limitations of the sensory mechanisms, the particular flight maneuvers that can lead to spatial disorientation, and the conditions where errors in perception are most likely to occur.

(2) Instrument training must be performed on a regular basis in order to maintain proficiency. It also reinforces the skills necessary for a good instrument cross check.

b. Fly the aircraft.

(1) Never try to fly both VMC and IMC at the same time. If you lose sight of the ground or significant objects, transition to the instruments and perform the emergency IMC procedures.

(2) Never fly without visual reference points (either an actual horizon or an artificial horizon).

(3) Utilize continuous scanning techniques during the day and during night operations. Never stare (either at lights or objects).

c. Instrumentation.

(1) Trust your instruments.

(2) Cockpit design: Position new equipment within the cockpit in areas that reduce the necessity for head movements. Ideally, instruments should be as easy to interpret as external cues.

d. Avoid self-imposed stressors. They make one more susceptible to sensory illusions.

<u>NOTES</u>: Briefly explain the acronym "DEATH".

NOTE: **NOTE:** Conduct a check on learning and summarize the learning/step activity.

CHECK ON LEARNING: <u>NOTE</u>: Conduct a check on learning and summarize the ELO.

K. ENABLING LEARNING OBJECTIVE

ACTION:	Identify the corrective actions to treat spatial disorientation.
CONDITIONS:	While serving as an aircrew member.
STANDARDS:	IAW FM 3-04.301 and the Fundamentals of Aerospace Medicine.

1. Learning Step / Activity 1. Provide instruction on the corrective actions to treat spatial disorientation.

Method of Instruction: Conference / Discussion
Instructor to Student Ratio: 1:50
Time of Instruction: 5 mins
Media: Large Group Instruction

a. Transfer control of the aircraft if there are two pilots (seldom will both pilots experience disorientation at the same time).

b. Delay intuitive reactions.

c. Refer to the instruments immediately upon losing the horizon as reference.

d. Develop and maintain instrument crosschecks.

e. Trust your instruments!

NOTE: Conduct a check on learning and summarize the learning activity.

CHECK ON LEARNING: NOTE: Conduct a check on learning and summarize the ELO.

SECTION IV. SUMMARY

Method of Instruction: Conference / Discussion Instructor to Student Ratio is: 1:50 Time of Instruction: 5 mins Media: Large Group Instruction

Check on Learning

a. Solicit student questions and explanations.

b. Questions and answers.

QUESTION: What are the three main terms used in Spatial Disorientation?

ANSWER: Vertigo, sensory illusion, and spatial disorientation.

QUESTION: Name the two types of vision used in orientation.

ANSWER: Focal (Central) vision, Ambient (Peripheral) vision.

QUESTION: Name the different visual illusions.

ANSWER: Relative motion, false horizons, depth perception, structural, fascination (fixation), size-distance, altered planes of reference.

QUESTION: Name the components of the vestibular system.

ANSWER: Semicircular canals and otolith organs.

c. Correct any misunderstandings.

Review / Summarize Lesson

This lesson has covered ways to manage the effects of spatial disorientation. You should now be prepared for the spatial disorientation portion of the one-hour exam.

SECTION V. STUDENT EVALUATION

Testing Requirements	**NOTE:** Describe how the student must demonstrate accomplishment of the TLO. Refer student to the Student Evaluation Plan. Each student will be evaluated on this block of instruction during the 50 question comprehensive aeromedical exam. This exam will be conducted on the last day of aeromedical training in building 301, classroom x-110.
Feedback Requirements	**NOTE:** Feedback is essential to effective learning. Schedule and provide feedback on the evaluation and any information to help answer students' questions about the test. Provide remedial training as needed. a. Each student will be informed of his/her score immediately after the examination is graded. b. Students who do not pass this examination be re-trained and re-tested within 24 hours after test failure .

Appendix A - Viewgraph Masters (N/A)

Appendix B - Test(s) and Test Solution(s) (N/A)

Appendix C - Practical Exercises and Solutions

PRACTICAL EXERCISE(S)/SOLUTION(S) FOR LESSON 1: U3004505 version 1

PRACTICAL EXERCISE SHEET 1

Title

SPATIAL DISORIENTATION AND SENSORY ILLUSIONS OF FLIGHT

Lesson Number / Title

U3004505 version 1 / Spatial Disorientation and Sensory Illusions of Flight

Introduction

Motivator

NOTES: The instructor may use a motivator of his or her choice as long as it gains the student's attention, states the need for this training, and explains the terminal learning objective. The instructor must relate the motivator to the TLO. Suggested motivator is as follows:

"Throughout the evolution of man, he has acquired sensory systems well suited for maneuvering under his own power on the surface of the earth, but poorly suited for flying. The sudden entry into the aerial environment resulted in a mismatch between the orientation demands of the new environment and the innate ability to orient oneself. The manifestation of this mismatch is spatial disorientation. Spatial disorientation contributes more to aircraft accidents than any other physiological problem in the aerial environment. From 1987 to 1995, 291 class A-C accidents were directly related to spatial disorientation. The results of these accidents were 110 fatalities and over 468 millions dollars in damage to the aircraft. It can strike at virtually anytime and place and in any mode of flight. Our goal today is to familiarize you with spatial disorientation so when you do experience it, you are able to recognize what is happening and overcome the effects."

Terminal Learning Objective

NOTE: The instructor should inform the students of the following Terminal Learning Objective covered by this practical exercise.

At the completion of this lesson, you [the student] will:

Action:	Manage the effects of spatial disorientation in flight.
Conditions:	While performing as an aircrew member.
Standards:	In accordance with (IAW) FM 3-04.301and the Fundamentals of Aerospace Medicine.

Safety Requirements

Student MUST wear seat belt in chair.

Risk Assessment

Low

Environmental Considerations	None.
Evaluation	”Each student will be evaluated on this block of instruction during the comprehensive aeromedical exam. This exam will be conducted on the last day of aeromedical training in building 301, classroom x-110.“
Instructional Lead-In	The classes you have attended here at the School of Aviation Medicine have prepared you to manage the effects of flight on the human body. Today we will continue that training be discussing the effects of spatial disorientation and sensory illusions.
Resource Requirements	**Instructor Materials:** Lesson plan for Spatial Disorientation and Sensory Illusions in Flight and FM 1-301. **Student Materials:** Spatial Disorientation and Sensory Illusions in Flight Student handout.
Special Instructions	

Procedures

SPECIAL INSTRUCTIONS: Rotation speed of the Barany Chair will be kept below 25 rpm. The seat belt will be used for all students. Rides will be limited to two demonstrations per student. More than two demonstrations may result in nausea and/or vomiting.

CAUTION: Due to the nature of the training, there is a possibility that a student may become sick. Reactions to the various illusions will vary. They may be very mild too severe. The seat belt must be securely fastened on all demonstrations.The instructor must be prepared to assist subjects during a reaction to ensure subjects safety.

PROCEDURES:

1. Preparation of all demonstrations.

    a. Seat student in chair.

    b. Fasten seat belt.

    c. Have the student don a helmet, secure the chin strap, and close his or her eyes.

2. Demonstration of fluid equilibrium in the semi-circular canals: Show that a state of equilibrium in the semi-circular canals can be induced in a constant turn.

a. Prepare student as outlined in paragraph 1a.

b. Have subject displace the cyclic to indicate direction of turn as "reported" to him by his vestibular apparatus. A return to the "neutral position" will indicate equilibrium.

c. Spin the chair in a clockwise direction momentarily and then counter-clockwise so the students can see that the subject can tell direction.

d. Begin smooth acceleration in either direction to approximately 18-25 rpm.

e. When subject "reports" equilibrium (as indicated by neutral cyclic), slow the rate to 2-3 rpm and point out reaction to students (should indicate an opposite direction with cyclic).

f. Stop chair and raise blindfold flap to allow subject to regain orientation.

3. Demonstrate nystagmus (rapid back and forth movement of the eyes induced by stoppage of a constant turn).

a. Prepare student as outlined in paragraph 1a.

b. Rotate chair with subject in sitting position, head upright, eyes closed.

c. Rotate for 20-30 seconds at constant rate.

NOTE: Ensure class is positioned so that they are able to view demonstrator's eyes when the chair is stopped. During rotation explain vestibulo-ocular reflex to the class.

d. Stop chair with subject facing class and have him or her open their eyes.

(1) Class. Observe typical rapid horizontal movement of the eyes.

(2) Subject. What apparent motion, if any is noted?

4. Coriolis illusion demonstration. The false perception of rolling, yawing, and pitching at the same time.

NOTE: Head positions for inducing the various forms of the coriolis illusion.

a. Position 1 (a strong illusion of falling forward). Have student grip cyclic and rest left hand on top of cyclic, palm down. Have student lean forward and turn head 90 degrees too left, placing the right ear on top of the left hand. Begin slow clockwise rotation to approximately 18-25 rpm. Continue rotation until student indicates vestibular sensation of rotation until student indicates vestibular sensation of rotation has diminished. Stop the Barany Chair and have him sit up and use the cyclic to control the apparent motion of the chair.

NOTE: A strong illusion of falling forward can be overwhelming, so be prepared to open visor on helmet to allow student to regain orientation, or have student open eyes and fixate on an object. Tell students the chair is stopped to ensure safe control of student, however, stress the continued motion of the aircraft.

b. Position 2 (coriolis falling backwards). Have student grip cyclic and rest left hand on top of cyclic, palm down. Have student lean forward and turn head 90 degrees too left, placing the right ear on top of the left hand. Begin slow counterclockwise rotation to approximately 18-25 rpm. Continue rotation until student indicates vestibular sensation of rotation has diminished. Stop the Barany Chair and have him sit up and use the cyclic to control the apparent motion of the chair.

NOTE: A strong illusion of falling backwards can be overwhelming, be prepared to open the visor on the helmet to allow the student to regain orientation, or have student open eyes and fixate on an object.

c. Position 3 (the coriolis snap roll). Have student tilt head rearward/look up toward the ceiling and begin slow clockwise turn to 18-25 rpm. When the subject reports turning sensation has ceased, have him look down abruptly towards his belt buckle.

NOTE: Reaction is as if the chair had entered a steep diving/climbing turn or perhaps a snap roll. Some students report they feel a violent spin.

d. Position 4 (the leans). Have student clasp hands behind head (POW) and lean forward, head between knees. Do not allow student to brace elbows (take away a small measure of proprioception) and begin a slow clockwise or counterclockwise turn to 15-20 rpm. When student reports turn stopped, have him sit upright and point straight up.

NOTE: Reaction should be the leans. Student will point 30 degrees from true vertical. Also a roll to the right will be detected. Rotary nystagmus should be noted.

e. Position 5. Begin counterclockwise rotation of 18-25 rpm. Have student tilt head to right over right shoulder so that it remains in a 90-degree rotation plane. When student report that turn has stopped, stop chair and have student sit up and "fly" the aircraft.

NOTE: Reaction will be that of severe dive and pitch under.

CAUTION: Reaction may be violent. Be prepared to open helmet visor to allow subject to reestablish orientation.

Feedback Requirements	a. Each student will be informed of his/her score immediately after the examination is graded. b. Students who do not pass this examination be re-trained and re-tested within 24 hours after test failure.

**SOLUTION FOR
PRACTICAL EXERCISE SHEET 1**

At the completion of this lesson the instructor will conduct a critique/after action review.

Appendix D - Student Handouts (N/A)